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## Economic Commission for Europe

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**World Forum for Harmonization of Vehicle Regulations**

**Working Party on General Safety Provisions**

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Item 6(b) of the provisional agenda
**Amendments to gas-fuelled vehicle regulations – Regulation No. 110 (CNG and LNG vehicles)**

# Proposal for amendments to Regulation No. 110 (CNG and LNG vehicles)

## Submitted by the expert from the International Organization for Standardization *

The text reproduced below was prepared by the expert from the International Organization for Standardization (ISO) to harmonize the requirements on Compressed Natural Gas (CNG) and/or Liquefied Natural Gas (LNG) vehicles of UN Regulation No. 110 with those of the international standard ISO 11439:2013 (see report ECE/TRANS/WP.29/GRSG/91, para. 28). It is based on informal document GRSG-113-02 distributed during the 113th session of the Working Party on General Safety Provisions (GRSG). The modifications to the current text of UN Regulation No. 110 are marked in bold characters for new and strikethrough for deleted characters.

* In accordance with the programme of work of the Inland Transport Committee for 2016–2017 (ECE/TRANS/254, para. 159 and ECE/TRANS/2016/28/Add.1, cluster 3.1), the World Forum will develop, harmonize and update Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

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# I. Proposal

*Paragraph 2. (References),* amend to read:

## "2. References

The following standards contain provisions that, through reference in this text, constitute provisions of this Regulation.

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| ASTM Standards* | |
| ASTM B117-90 | Test method of Salt Spray (Fog) Testing |
| ASTM B154-92 | Mercurous Nitrate Test for Copper and Copper Alloys |
| ASTM D522-92 | Mandrel Bend Test of attached Organic Coatings |
| ASTM D1308-87 | Effect of Household Chemicals on Clear and Pigmented Organic Finishes |
| ASTM D2344-84 | Test Method for Apparent interlaminar Shear Strength of Parallel Fibre Composites by Short Beam Method |
| ASTM D2794-92 | Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact) |
| ASTM D3170-87 | Chipping Resistance of Coatings |
| ASTM D3418-83 | Test Method for Transition Temperatures Polymers by Thermal Analysis |
| **ASTM D4814** | **Standard Specification for Automotive Spark-Ignition Engine Fuel** |
| ASTM E647-93 | Standard Test, Method for Measurement of Fatigue Crack Growth Rates |
| ASTM E813-89 | Test Method for $J_{IC}$, a Measure of Fracture Toughness |
| ~~ASTM G53-93~~ | ~~Standard Practice for Operating Light and Water Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of non-metallic materials~~ |
| **ASTM G154-12a** | **Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials** |
| BSI Standards† | |
| BS 5045 | Part 1 (1982) Transportable Gas Containers – Specification for Seamless Steel Gas Containers Above 0.5 litre Water Capacity |

* American Society for Testing and Materials.

† British Standards Institution.

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|---|---|
| BS 7448-91 | Fracture Mechanics Toughness Tests Part I – Method for Determination of $K_{IC}$, Critical COD and Critical J Values of BS PD 6493-1991. Guidance an Methods for Assessing the A Acceptability of Flaws in Fusion Welded Structures; Metallic Materials |
| EN Standards[‡] | |
| EN1251-2 2000 | Cryogenic vessels. Vacuum insulated vessels of not more than 1,000 litres volume |
| EN 895:1995 | Destructive tests on welds in metallic materials. Transverse tensile test |
| EN 910:1996 | Destructive test methods on welds in metallic materials. Bend tests |
| EN 1435:1997 | Non-destructive examination of welds. Radiographic examination of welded joints |
| EN 6892-1:2009 | Metallic materials. Tensile test |
| EN 10045-1:1990 | Charpy impact test on metallic materials. Test method (V- and U-notches) |
| ISO Standards[§] | |
| ISO 37 | Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties. |
| ISO 148-1983 | Steel – Charpy Impact Test (v-notch) |
| ISO 188 | Rubber, volcanized or thermoplastic – Accelerated ageing and heat resistance tests |
| ISO 306-1987 | Plastics - Thermoplastic Materials – Determination of Vicat Softening Temperature |
| ~~ISO 527 Pt 1 93~~ | ~~Plastics – Determination of Tensile Properties – Part 1: General principles~~ |
| **ISO 527-2** | **Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics** |
| ISO 642-79 | Steel-Hardenability Test by End Quenching (Jominy Test) |
| ISO 12991 | Liquefied natural gas (LNG) – transportable tanks for use on-board vehicles |
| ISO1307 | Rubber and plastics hoses – Hose sizes, minimum and maximum inside diameters, and tolerances on cut-to-length hoses |
| ISO 1402 | Rubber and plastics hoses and hose assemblies – Hydrostatic testing |

[‡] European Norm.

[§] International Organization for Standardization.

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| ISO 1431 | Rubber, vulcanized or thermoplastic – Resistance to ozone cracking |
| ISO 1436 | Rubber hoses and hose assemblies – Wire-braid-reinforced hydraulic types for oil-based or water-based fluids – Specification |
| ISO 1817 | Rubber, vulcanized or thermoplastic – Determination of the effect of liquids |
| ISO 2808-91 | Paints and Varnishes – Determination of film Thickness |
| ~~ISO 3628-78~~ | ~~Glass Reinforced Materials – Determination of Tensile Properties~~ |
| ISO 4080 | Rubber and plastics hoses and hose assemblies – Determination of permeability to gas |
| ISO 4624-78 | Plastics and Varnishes – Pull-off Test for adhesion |
| ISO 4672 | Rubber and plastics – Sub-ambient temperature flexibility tests |
| ISO **6892** ~~6982-84~~ | Metallic Materials – Tensile Testing |
| ISO 6506-1981 | Metallic Materials – Hardness test – Brinell Test |
| ISO 6508-1986 | Metallic Materials – Hardness Tests – Rockwell Test (Scales, ABCDEFGHK) |
| ISO 7225 | Precautionary Labels for Gas Cylinders |
| ISO~~/DIS~~ 7866~~-1992~~ | Refillable ~~Transportable~~ seamless aluminium alloy cylinders ~~for Worldwide Usage~~ – Design, **construction and testing** ~~Manufacture and Acceptance~~ |
| ISO 9001:1994 | Quality Assurance in Design/Development. Production, Installation and Servicing |
| ISO 9002:1994 | Quality Assurance in Production and Installation |
| ISO/DIS 12737 | Metallic Materials – Determination of the Plane-Strain Fracture Toughness |
| ISO12991 | Liquefied natural gas (LNG) – transportable tanks for use on board of vehicles |
| ISO14469-1:2004 | Road Vehicles: compressed natural gas CNG refuelling connector: Part I: 20 MPa (200 bar) connector |
| ISO14469-2:2007 | Road Vehicles: compressed natural gas CNG refuelling connector: Part II: 20 MPa (200 bar) connector |
| ISO15500 | Road vehicles – Compressed natural gas (CNG) fuel system components |
| ISO 21028-1:2004 | Cryogenic vessels – Toughness requirements for materials at cryogenic temperature – Part I: Temperatures below -80 °C |

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|---|---|
| ISO 21029-1:2004 | Cryogenic vessels – Transportable vacuum insulated vessels of not more than 1,000 litres volume – Part I: Design, fabrication, inspection and tests |
| ISO/IEC Guide 25-1990 | General requirements for the Technical Competence of Testing Laboratories |
| ISO/IEC Guide 48-1986 | Guidelines for Third Party Assessment and Registration of Supplies Quality System |
| ~~ISO/DIS 9809~~ | ~~Transportable Seamless Steel Gas Cylinders Design, Construction and Testing Part I: Quenched and Tempered Steel Cylinders with Tensile Strength < 1,100 MPa~~ |
| **ISO 9809-1** | **Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 1: Quenched and tempered steel cylinders with tensile strength less than 1,100 MPa** |
| ISO 11439 | Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles |
| NACE Standard[**] | |
| NACE TM0177-90 | Laboratory Testing of Metals for Resistance to Sulphide Stress Cracking in $H_2S$ Environments |
| ECE Regulations[††] | |
| Regulation No. 10 | Uniform provisions concerning the approval of vehicles with regard to electromagnetic compatibility |
| USA Federal Regulations[‡‡] | |
| 49 CFR 393.67 | Liquid fuel tanks |
| SAE Standards[§§] | |
| SAE J2343-2008 | Recommended Practice for LNG Medium and Heavy-Duty Powered Vehicles" |

*Annex 3A*

*Paragraph 6.3.6.*, amend to read:

"6.3.6. Plastic liners

The tensile yield strength and ultimate elongation shall be determined in accordance with paragraph A.22. (Appendix A to this annex). Tests shall demonstrate the ductile properties of the plastic liner material at temperatures of -50 °C or lower by meeting the values specified by the manufacturer; the

** National Association of Corrosion Engineers.
†† United Nations Economic Commission for Europe; Regulations.
‡‡ United States of America Federal Regulations.
§§ Society of Automotive Engineers.

polymeric material shall be compatible with the service conditions specified in paragraph 4. of this annex. In accordance with the method described in paragraph A.23. (Appendix A to this annex), the softening temperature shall be at least ~~90 °C, and the melting temperature at least~~ 100 °C."

*Paragraph 6.12.*, amend to read:

"6.12. Exterior environmental protection

The exterior of cylinders shall meet the requirements of the environmental test conditions of paragraph A.14. (Appendix A to this annex). Exterior protection may be provided by using any of the following:

(a) A surface finish giving adequate protection (e.g. metal sprayed on aluminium, anodizing); or

(b) The use of a suitable fibre and matrix material (e.g. carbon fibre in resin); or

(c) A protective coating (e.g. organic coating, paint) that shall meet the requirements of paragraph A.9. (Appendix A to this annex).

Any coatings applied to cylinders shall be such that the application process does not adversely affect the mechanical properties of the cylinder. The coating shall be designed to facilitate subsequent in service inspection and the manufacturer shall provide guidance on coating treatment during such inspection to ensure the continued integrity of the cylinder.

~~Manufacturers are advised that an environmental performance test that evaluates the suitability of coating systems is provided in the informative Appendix H to this annex.~~"

*Annex 3A, Appendix A*

*Paragraph A.14.*, amend to read (inserting new sub-paragraphs A.14.1. to A14.6., based mainly on the text of Annex 3A, Appendix H):

"A.14. ~~Acid e~~**E**nvironmental test

~~On a finished cylinder the following test procedure should be applied:~~

~~(a) Exposing a 150 mm diameter area on the cylinder surface for 100 hours to a 30 per cent sulfuric acid solution (battery acid with a specific gravity of 1.219) while the cylinder is held at 26 MPa;~~

~~(b) The cylinder shall then be burst in accordance with the procedure defined in paragraph A.12. above and provide a burst pressure that exceeds 85 per cent of the minimum design burst pressure.~~

**A.14.1. Scope**

**This test is applicable to type CNG-2, CNG-3 and CNG-4 designs only.**

**A.14.2. Cylinder set-up and preparation**

**The upper section of the cylinder will be divided into 5 distinct areas and marked for preconditioning and fluid exposure (see Figure A.1). The areas will be nominally 100 mm in diameter. The areas shall not overlap on the cylinder surface. While convenient for testing, the areas need not be oriented along a single line, but shall not overlap the immersed section of the cylinder.**

**Although preconditioning and fluid exposure is performed on the cylindrical section of the cylinder, all of the cylinder, including the domed sections, should be as resistant to the exposure environments as are the exposed areas.**

**Figure A.1**
**Cylinder orientation and layout of exposure areas**

**A.14.3. Pendulum impact preconditioning**

**The impact body shall be of steel and have the shape of a pyramid with equilateral triangle faces and a square base, the summit and the edges being rounded to a radius of 3 mm. The centre of percussion of the pendulum shall coincide with the centre of gravity of the pyramid; its distance from the axis of rotation of the pendulum shall be 1 m. The total mass of the pendulum referred to its centre of percussion shall be 15 kg. The energy of the pendulum at the moment of impact shall be not less than 30 Nm and as close to that value as possible.**

**During pendulum impact, the cylinder shall be held in position by the end bosses or by the intended mounting brackets. The cylinder shall be un-pressurized during preconditioning.**

**A.14.4. Environmental fluids for exposure**

**Each marked area is to be exposed to one of five solutions for 30 minutes. The same environment shall be used for each location throughout the test. The solutions are:**

| | |
|---|---|
| **Sulphuric acid:** | **19 per cent solution by volume in water;** |
| **Sodium hydroxide:** | **25 per cent solution by weight in water;** |
| **5% Methanol/95% gasoline:** | **gasoline concentration of M5 fuel meeting the requirements of ASTM D4814;** |
| **Ammonium nitrate:** | **28 per cent by weight in water;** |
| **Windshield washer fluid** | **50 per cent by volume solution of methyl alcohol and water.** |

**When exposed, the test sample will be oriented with the exposure area uppermost. A pad of glass wool (approximately 0.5 mm thick and between 90 and 100 mm in diameter) shall be placed on the exposure area. Apply an amount of the test fluid to the glass wool sufficient to ensure that the pad is wetted evenly across its surface and through its thickness for the duration of the test, and that the concentration of the fluid is not changed significantly during the duration of the test.**

**A.14.5. Pressure cycle and hold**

**The cylinder shall be hydraulically pressure cycled between not less than 2 MPa and not more than 26 MPa for a total of 3,000 cycles. The maximum pressurization rate shall be 2.75 MPa per second. After**

**pressure cycling, the cylinder shall be pressurized to 26 MPa and held at that pressure a minimum of 24 hours and until the elapsed exposure time (pressure cycling and pressure hold) to the environmental fluids equals 48 hours.**

**A.14.6. Acceptable results**

**The cylinder shall be hydraulically tested to destruction in accordance with the procedure in paragraph A.12. The burst pressure of the cylinder shall be not less than 80 per cent of the minimum design burst pressure."**

*Paragraph A.16.*, amend to read:

"A.16. Penetration tests

A cylinder pressurised to 20 MPa ± 1 MPa with compressed gas shall be penetrated by an armour piercing bullet with a diameter of 7.62 mm or greater. The bullet shall completely penetrate at least one side wall of the cylinder. **For type CNG-1 designs, the projectile shall impact the side wall at 90°.** For type CNG-2, CNG-3 and CNG-4 designs, the projectile shall impact the side wall at an approximate angle of 45°. The cylinder shall reveal no evidence of fragmentation failure. Loss of small pieces of material, each not weighing more than 45 grams, shall not constitute failure of the test. The approximate size of entrance and exit openings and their locations shall be recorded."

*Paragraph A.22.*, amend to read:

"A.16. Tensile properties of plastics

The tensile yield strength and ultimate elongation of plastic liner material shall be determined at -50 °C using ISO **527-2** ~~3628~~, and meet the requirements of paragraph 6.3.6. of Annex 3A."

*Pragraph A.23.*, amend to read:

"A.23. ~~Melting~~ **Softening** temperature of plastics

Polymeric materials from finished liners shall be tested in accordance with the method described in ISO 306~~, and meet the requirements of paragraph 6.3.6. of Annex 3A~~. **The softening temperature shall be at least 100°C.**"

*Annex 3A, Appendix H*, shall be deleted.

## II. Justification

A detailed justification on the modification proposed above can be found in GRSG-113-02, available at: www.unece.org/trans/main/wp29/wp29wgs/wp29grsg/grsginf113.html.